ORIENTATION CALENDAR IN MESOAMERICA: HYPOTHESIS CONCERNING THEIR STRUCTURE, USE AND DISTRIBUTION*

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Introduction

The basis for any calendar is the observation of the path of the sun, moon and also the stars which have since time immemorial determined the ordering and measurement of time for Man. These very astronomical phenomena also give him the means with which to find his way in his environment —making it possible to recognize and determine the cardinal directions. By *orientation calendars* we mean such calendars whose structure and subdivisions are derived from events resulting from the annual motion of the sun on the horizon. The direction towards specific points on the horizon was fixed purposefully, following ancient traditions, by tracing orientation lines in the landscape; in many cases, these lines passed through buildings oriented in these very directions.[1] In the last two decades it has become increasingly evident that these direction lines were used in Mexico and in the Maya area with great frequency, precision and on a wide scale and were applied widely in the planning of towns, ceremonial centers and of settlements with their surrounding fields. The solstitial points with the sunrises and sunsets on the days of the summer and winter solstices were of fundamental importance to the inhabitants of Mesoamerica. They provided the basis for their conception of cosmological space organized around four main points on the horizon, a conception that is represented on the Aztec day sign *olin* and can be found as early as in

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1 "In many cultures one finds that an orientation calendar, a scheme for counting the days, derived by following the annual course of the sun on the horizon, is deeply rooted in a tradition of deliberately laying out alignments to various points in the landscape (...) Simply stated, an orientation is an alignment with a purpose." (Aveni and Hartung 1986, p. 1).

pre-Classic times on an Olmec symbol (Broda 1982 p. 87; Koehler 1982). The solstitial directions explain the deviation of about 25°, which is the greatest deviation that orientation lines show from our usual cardinal directions, a deviation rarely exceeded, which is documented in the ground-plan of the pyramid and town of Cholula. Further points were also of importance, namely those at which in tropical latitudes, *i.e.* between the Tropics, the sun appears or disappears on the horizon on the two days of its passage through the zenith. After they had been discovered, and when exact measurements were available, these lines, especially the directions of the zenith passage, were easy to explain. Many other orientation lines, insofar as they have been noticed and measured (*c.f.* Aveni 1980, Appendix A) —including the axis of Teotihuacan, remained unexplained for a long time or could not be satisfactorily interpreted. By means of solar calendars of a hypothetical nature, it has gradually become possible to identify all frequently ocurring direction lines as elements of orientation calendars.

Orientation calendars for the Maya area

It was Robert H. Merrill who proposed a hypothetical solar calendar for Copán/Guatemala, situated in latitude 14°52′ N. This calendar not only contains equinoxes and zenith passages, but also a direction line that was important for the planning of Copán. It is the line between stela 12 in the East and stela 10 in the West whose orientation (azimuth 279°) was measured as a deviation of 9° from the West counted in a clockwise direction.[2] In this way a solar calendar was turned into an orientation calendar (Aveni and Hartung 1976; Merrill 1945; Tichy 1976/81 p. 235). Seen from stela 12, the sun sets behind stela 10 on April 12 and August 30/31. The April date is 20 days, or one *uinal* of the Maya calendar (the latter with its 18 periods of 20 days each and 5 remaining days) after the Spring equinox, or more precisely, after the mid-year day on March 24. This day lies exactly half-way between the winter and summer solstices, in contrast to the Spring equinox on March 21. The reason for this difference is that during the winter half-year of the northern hemisphere the earth is closer to the sun and travels more quickly compared to the summer half-year when it is at a greater distance from the sun. In addition, the April date occurs, in the latitude of Copán, almost 20 days before the first zenith passage of the sun on May 1st.

[2] In this way all the direction angles are indicated here as deviations from one of the four cardinal points.

In table 1 an extended versión of Merrill's hypothetical orientation calendar is presented as an example of a calendar with 20 day periods. In order to make use of its properties —in case it existed at all— it needed to be regularly adapted to the events of the solar year by using a yet unknown method of inserting leap days into it. As the calendar was made for Copán in a latitude which is ideally suited to this purpose, two initial days of its periods coincide almost exactly with the days of the zenith passages of the sun. On these days (May 3 and August 11).

TABLE 1: Orientation Calendar for Copán (14° 52′ n.L.) with 20-day periods after Merrill (1945), adapted and extended (Tichy 1976/81, p. 235).

1st Day of the period	*Solar Events and Alignments in Copán*	*Deviation * of Sunrise or Sunset*
	7/2 - 11/2 5 uayeb	
12/2		14° 12′
4/3	Temple 22, façade; 7° 04′	6° 42′
24/3	Midyear day.—Hierogl. Stairway 1° 15′	1° 26′
13/4	Axis line Stelae 12 - 10; 9°	9° 20′
3/5	Zenith passage (May 1st)	16° 12′
23/5		21° 18′
12/6		24° 00′
2/7		23° 54′
22/7		21° 02′
11/8	Zenith passage (August 12)	15° 51′
31/8	Axis line Stelae 12 - 10; 9°	8° 59′
20/9	Midyear day. Hierogl. Stairway 1° 15′	1° 10′
10/10	Temple 22, façade; 7° 04′	6° 50′
30/10		14° 14′
19/11		20° 08′
9/12		23° 39′
29/12		24° 05′
18/1		21° 18′

* Deviation of sunrise in the winter half-year, deviation of sunset in the summer half year.

Calculation based on a horizon altitude of 0.5° and an atmospheric refraction of 0.5°. Th position of sunrise on sunset will appear on the astronomical horizon A_0.

the sun sets with the orientation angle of West 16° North. This direction, however, which has such a wide distribution in Mesoamerica and is so clearly present at Teotihuacan, happens to coincide with a zenith position only in this latitude. Yet, this orientation line does not occur in the architecture of Copán, nor does the 14° direction connected with the initial day of the calendar on February 12. On the other hand there exists evidence for the lines with the deviations of 1° and 7°, which coincide with the initial days of two calendar periods and are represented in table 1.

The orientation calendar that could be established for Uxmal (latitude 20.5° N; Aveni and Hartung 1986, table 2) shows the same sequence of periods. It, too, includes the days of the zenith passages of the sun, May 23 and July 22 in its latitude. In the *House of the old Woman* the corresponding orientation line was laid down with a deviation of 22° that seems to have been used deliberately when the building was planned. The solstitial direction was employed in other architectural contexts as were the directions with 1° and 9°.

The ritual calendar of the Aztecs, as described by Sahagún, that I have interpreted as a fixed solar calendar, also had the same structure as the orientation calendars of Copán and Uxmal (Tichy 1976a, 1976/81, 1980). However, this calendar does not follow the motion of the sun as closely as do the two calendars of 15° and 20.5° n.L., for in the Aztec case the days of zenith passage do not coincide with the initial days of 20-day-periods. What all three have in common is the symmetrical arrangement with regard to the solstices, although the solstices themselves have no particular calendrical importance.

We now know that in other places of the Maya area the 9° direction was also commonly applied in the planning of towns etc. Also used were the solstice directions (25°-26°), the mid-year direction (approximately 1°), various zenith position directions dependent upon the latitude of the place in question (Tichy 1980 table 2; 1985 table 3), the *Teotihuacan direction* of 15.5° (Malmstrom 1981) to 17° (Tichy 1982), which needs a particular explanation in each case and finally, direcctions of architecturally marked lines with deviations of 5°, 11° 14° and 18° degrees counted in a clockwise direction (Aveni and Hartung 1986, table 1).

As the hypothetical orientation calendar shows, the 14° direction can be explained with the line to the sunrise on February 12 and October 30. Between these two dates there are 260 days or 13 periods of 20 days, which might also belong to a special agrarian calendar. Although we have now explained these orientation lines —which are probably the most important and frequent—, in terms of dates and events, of the solar year, there remain yet the angle values of 5°, 11° and 18° which cannot be related to positions of the sun on initial days of the orientation calendar (see table 1).

However, the direction lines found by Aveni and Hartung to be particularly frequent in the Maya area, show in general another peculiarity. If they are ordered according to their numerical sequence, we find an angle series of 1°, 5°, 9° 11° 14°, 16° 18°, 22° 25°. Given the fact that the angle values 1°, 5°, 9° 14°, 18°, 22 are rarely found outside the Maya area, they might be called the *Maya sequence* of an as yet undiscovered orientation calendar with some specific functions. Besides, these values differ from each other by 4 to 5 degrees, respectively. An observation which exactly parallels this has already been made with a sequence of values from the Mexican highlands (Tichy 1974).

Orientation calendars for Central Mexico

Unlike the many ceremonial centers of the Maya area with their often very varied orientation lines within the same site, in Central Mexico there are far fewer buildings that can easily be measured and even those existing have more or less the same axial position within respective ceremonial sites and settlement patterns. The best known example is Teotihuacan with its deviation of 15.5° - 17°. Because of its particular frequency this direction has been referred to as the 17° *family and* numerous scholars have expressed a variety of opinions intended to explain this direction (Malmstrom 1981; Tichy 1976a, 1982; Aveni 1980 p. 226). Most unusual is the axial position of the procession road leading towards the Cerro Gordo, which constitutes a topographical element. Although other orientation lines had been measured in the pre-Columbian architecture of Central Mexico, their total number was nevertheless too small to draw unambiguous conclusions from their frecuency distribution (Aveni 1980 fig. 74b). In that case another method was more successful which considered the global settlement patterns and based its measurements on the buildings succeeding pre-Hispanic ceremonial structures, i.e. the churches in the basins of Mexico, Puebla-Tlaxcala and Oaxaca. Aerial photographs and topographical maps took the place of measurements in the field by means of compass and surveyor's transit, though compass measurements were made to check the findings (Tichy 1974, 1976a, Storck 1980). The 280 churches in the Basin of Mexico alone made it possible to establish a clear frequency distribution. It permitted to identify a sequence of angles with the values of 2°, 7°, 11°, 20° and 25° (Tichy 1976/81; see fig. 1). On the basis of the regular intervals in this series of 4°-5° it was concluded that there might have existed an underlying angular unit of 4.5°, or 1/20 of a right angle. In comparision to the Maya sequence observed in the previous section which demonstrated the same intervals, this apparently is a *Central Mexican Sequence.*

However, the geometry of an angle observation system structured in this way did not seem to be a sufficent explanation for the orientations observed. So the attempt was made to find an orientation calendar. There remained the possibility of a fixed, *i.e.* a solar calendar (with leap days inserted in some way), which, according to Sahagun's description, contained 18 periods of 20 days and 5 *nemontemi* days. In contrast to the orientation calendar for the Maya area (table 1) that permits to explain six of the direction lines found there, including four of the Maya sequence, in the case of Central Mexico only two can be explained. One of them is the Tenochtitlan direction (7°) with sunrise on March 4 and October 10 and the Teotihuacan direction with sunset on May 3 and August 11. The date at the beginning of May is of great importance in the agrarian calendar because from then onwards the onset of the rainy season may be expected. Today the Feast of the Holy Cross is celebrated on May 3 with the corresponding ceremonies. For the low values of 1° - 2° the mid-year days may serve as an explanation, while for the direction of 20° it might be the days of the zenith passages in the latitude of 19° N, and for 25° the solstice days. But what explains the frequent direction of 11°-12°? The postulated orientation calendar does not include the 11°-12° direction nor the zenith passage and solstice directions. Only the mid-year days are found as the initial days of periods III and XII (Tichy 1976/81, fig. 10).[3] Does there exist, perhaps, a special orientation calendar for Central Mexico that includes the 11° direction as well as the solstices?

An orientation calendar with 13-day periods for Mesoamerica

The fact that in the two angle sequences of the Maya area and of Central Mexico, the individual orientation values are 4° - 5° degrees apart, raised the question of the intervals in days at which these angles occur at the horizon as solar positions. In order to answer this question it was sufficient to simply consider the data for the declination of the sun, for example in the *Anuario del Observatorio Nacional de México.* The result was more or less 13 days. The next step was then easy. A

[3] The use of names or numbers from the Aztec calendar, i.e. the correlation, is hypothetical and subject to criticism (Broda 1982, note 29; Graulich 1981, 1984).

calendar with 13-day periods had to be checked to see whether it could function as an orientation calendar. An attempet in this respect had been made before, however incompletely and concerning the 20 day periods; on that occasion I hypothesized a fixed *tonalpohualli* based on the reconstruction of the *fiestas movibles* according to Nowotny (1968) (Tichy 1976 a, table 3). The agrarian calendar presented by Girard (1962), a fixed *tzolkin* with 260 days from February 12 to October 31, was also taken into account; however, it was not noticed then that there is no difficulty in representing it as a calendar with 13-day periods and that in that case it reveals the desired properties (Tichy 1976/81 fig. 11).

The 260 days of the agrarian calendar found by Girard among the Chortí in the Highlands of Guatemala of which he describes the accompanying rites, remarkably enough can also be counted using 20 periods of 13 days. This opens up completely new aspects, especially if the calendar is completed to cover the whole year. The incentive to do so was the fact that between the zenith passages in Copán (15° n.L.) on August 12/13 and April 30/May 1st there is a period of 260 days, or 261 days to be more precise. This led Malmstrom (1973) to assume that the 260 day calendar must have originated at this latitude. After dividing this hypothetical "sacred calendar" into 20 periods of 13 days, the remaining 104 days, or 8 further such periods, were added. These are the 2 $\times$ 52 days in Girard's agrarian calendar that are situated on both sides of the summer solstice and are delimited by the days of the zenith passages (Tichy 1976 a, p. 140, 1976/81 tab. 4).

It can be seen from table 2 that all the important orientation lines correspond to calendrical dates with their respective positions of the sun at the horizon.[4] Because of these properties a calendar of this kind with 13-day periods and a remaining day might have been used by the Mesoamerican architects and town planners, but also as an agrarian calendar. It also contains the observational data for the whole of the winter half year, when the sky was largely free of clouds and solar observations were easier to carry out than in the vernal rainy season.

[4] The calculation is based on a horizon altitude of 0.5° and an atmospheric refraction of 0.5°. The position of sunrise or sunset will appear on the astronomical horizon A_o. If the horizon is more elevated, the position of the later sunrise during the winter half year is $A = A_o + \Delta A$, the position of the earlier sunset during the summer half year is $A = A_o - \Delta A$. The horizon altitude of 2.2° results in a shift in azimuth ΔA of 30.5′, 39′ and 42.5′ corresponding to the latitudes of 15°, 19° and 20°5, respectively.

TABLE 2: Hypothetical Solar Orientation Calendar with 13-day Weeks beginning with Winter Solstice and the angle sequences of 4.5°.

1st day of 13-day week	astronomical events agrarian cycle		clockwise deviation from W or E sunset in summer half-year sunrise in winter half-year	Lat. 15°N	19°N	20.5°N
22/12	Winter Solstice	WINTER H.-Y.	25	24°08'	24°39'	24°53'
4/1				23°24'	23°54'	24°07'
17/1			22	21°21'	21°47'	21°59'
30/1			18	17°52'	18°13'	18°23'
12/2	Beginning Agrarian Cycle		14	14°03'	14°19'	14°26'
25/2			9	9°14'	9°26'	9°31'
10/3			4	4°07'	4°10'	4°11'
23/3	Mid-year Day (Vern. Equinox	SUMMER HALF-YEAR	1	0°50'	0°50'	0°50'
5/4			6	6°05'	6°10'	6°13'
18/4			11	11°00'	11°12'	11°18'
1/5	1. Solar Zenith Passage Lat. 15°N		16	15°25'	15°42'	15°51'
14/5			20	19°07'	19°30'	19°40'
27/5	1. Solar Zenith Passage Lat. 21°16'			21°54'	22°21'	22°33'
9/6				23°36'	24°06'	24°19'
22/6	Summer Solstice		25	24°09'	24°39'	24°52'
5/7				23°28'	23°57'	24°10'
18/7	2. Solar Zenith Passage Lat. 21°16'N			21°39'	22°06'	22°18'
31/7			20	18°48'	19°10'	19°21'
11/8	2. Solar Zenith Passage Lat. 15°N		16	15°04'	15°21'	15°29'
26/8			11	10°40'	10°51'	10°56'
8/9			6	5°46'	5°51'	5°54'
21/9	Mid-year Day (Aut. Equinox)	WINTER H.-Y.		0°37'	0°35'	0°32'
4/10			4	4°18'	4°21'	4°23'
17/10			9	9°23'	9°33'	9°37'
30/10	Conclusion Agrarian Cycle		14	14°05'	14°21'	14°28'
12/11			18	18°09'	18°30'	18°41'
25/11			22	21°19'	21°46'	22°58'
8/12				23°23'	23°52'	24°06'
	21/12 one day rest					

Winter (Maya) Orientation Sequence: 4°-9°-14°-18°-22°-25°
Summer (Central Mexico) Orientation Sequence: 1°-6°-11°-16°-20°-25°.
Triangles: Difference 4°-5°.

Calculation based on a horizon altitude of 0.5° and an atmospheric refraction of 0.5°. The position of sunrise or sunset will appear on the astronomial horizon A_0.

The year beginning of this calendar has been placed on the day of the winter solstice, in contrast to Malmstrom (1973) who had it begin on the day of the second zenith passage of the sun in 15° n.L. The winter solstice year beginning makes this calendar valid for the whole of Mesoamerica. It also corresponds to the calendars of the Yucateco, Tzeltal, Tzotzil and Quiché, who in the middle pre-Classical period around 550 B.C. chose the winter solstice as the beginning of their calendar, as shown by the meaning of the names of the months (Bricker 1982, p. 103). While this was a rotating calendar, the hypothetical 13-day calendar must be a fixed sun calendar which needs to be repeatedly corrected. As it contains only one remaining day, the 28 weeks of 13 days only had to be extended by five days every 4 years.

What are the properties of the hypothetical orientation calendar with its 28 periods of 13 days?

a. It is very close to the actual motion of the sun. The initial days of 13-day periods coincide exactly with the solstices, the days between the equinoxes and mid-year days and, as with the 20-day calendar in table 1, there exists a coincidence for the zenith passage days at the latitudes of 15° and 21° n.L.

b. It contains the important dates of the agrarian year with its beginning and end as well as with the onset of the wet season at the beginning of May.

c. Its nature as orientation calendar is revealed by the fact that, taking into account the less than exact measuring procedures in pre-Hispanic times, it contains all the direction lines between the solstice points as lines towards sunrise or sunset points on the horizon.

d. The sequence of the direction values is different in the winter half-year and the summer half-year. In the winter, from September 21 to March 23, we find the sequence of 0°-4°-9°-14°-18°-22°-25°-22°-18°-14°-9°-4°.
However, in the summer the angle sequence is 1°-6°-11°-16°-20°-25°-20°-16°-11°-6°-1°.

e. It was necessary to observe the sunrises in order to fix the orientation lines in the winter half-year. In the summer half-year however, the directions of the sunsets were decisive to determine deviations from the cardinal points in a clockwise direction. As a result we get two different observational procedures and according to them, different sequences of direction angles are contained in the same observation calendar.

f. Both sequences of angles permit further observations. The differences between the individual angles for the periods between July 31 and November 12 and again between January 30 and May 14, calculated for the first days of the 13-day periods and for the latitude of 20.5° N., happen to be angles between 3°22′ and 5°24′, which amounts to an average of 4°31′.

Both series of angles are almost exactly regular and of equal intervals; this striking fact reveals a clear geometrical property of the orientation systems. Knowledge and application of these systems necessarily made it much easier to transfer certain orientation lines from one marked place of astronomic importance, an observatory —the point from where measurements were actually taken— towards ceremonial centers and settlements that still had to be planned and built. A report on the possible methods and "instruments" that may have been used in transferring such data or even measuring them on the basis of a standard angular unit appeared recently (Tichy 1988). Thus, new evidence has been accumulated to support the previously proposed regular sequence of angles at 4.5° intervals, i.e. 1/20 of a rigth angle, a unit that makes sense within the vigesimal system (Tichy 1974, 1976 a, 1976/81). The "summer sequence" of the orientation calendar contains the sequence of angles that was derived from the frequency distribution of the direction values in the Basin of Mexico, i.e. a case in which sunset was observed. The "winter sequence" includes the values from the Maya area given by Aveni and Hartung (1986) which had remained partly unexplained, in the latter case it appears that sunrise observations were made.

What is the connection between the hypothetical orientation calendar with 13-day periods and the one with 20-day periods? Certain correspondences are to be expected at the respective intervals of 3 × 13, i.e. approximately 40 days. Differences result, above all, from the varying direction of observation towards the East or West, at sunrise or sunset. According to the 20-day calendar, the 7° direction of Tenochtitlan can be observed on March 4 and October 10 at sunrise while according to the 13-day calendar, it corresponds to April 5 and September 8 at sunset. The 16° direction of Teotihuacan always occurs at sunset, in the 20-day calendar on May 3 and August 11, in the 13-day calendar on May 1 and August 13, i.e. the dates almost coincide. The 9° direction of Copán is found in both calendars, in the 20-day calendar of table 1 at sunset on April 12 and August 30/31, while in the 13-day calendar of table 2 it corresponds to sunrise on February 25 and October 17. Closer considerations and comparisions with the festival days that are known from the ethnohistorical and ethnological evidence are now required in order to determine which one of the two calendars is to be preferred, also in order to discover whether the calendar with the 13-day periods satisfies all the demands that can be made upon it as an orientation calendar or whether the 20-day calendar may have had its additional functions. The two dates established in Copán by the 9° line, which according to the 13-day calendar fall on February 25 and October 17, may have marked off an important agricultural period for the community.

It is hardly possible to define the separation line between the summer and the winter sequence as it occurs on the midyear-days which accordingly belong to both angle series. If the orientation —and numerical calendars are constructed symmetrically around the solstices, it is always these midyear-days which appear, situated as they are exactly between the Mesoamerican cardinal points and the cardinal directions of the solstices. If the direction lines to the position of the sun on these days have been marked by buildings, these deviate in a clockwise direction by approximately 1° from the equinoctial direction. The calendrical direction of the mid-year days seems to have been more important than those exact East and West points, which apparently do not occur at all in the architecture and town planning of Mesoamerica.

The table of measurements in Aveni (1980, Appendix A) contains examples of the mid-year direction: Xochicalco, Ballcourt Axis; Teopanzolco; Xochicalco has another especially interesting arrangement in the axes of structures C an D (measurement by Aveni, personal communication; Tichy 1978, fig. 3, 1985, p. 102); the orientation of the axis of group E in Uaxactún also follows this model (Thompson 1974 p. 95; Tichy 1976/81 fig. 8) and can be regarded as a true calendrical structure. Cacaxtla in Tlaxcala/Mex. also seems to follow the midyear direction in the line of the warrior mural (observation and map-checking made in 1985). Since Xochicalco and Cacaxtla show clear links with Maya culture, one might also consider assigning the mid-year direction as an architectural direction element to the Maya, i.e. to the winter series of the angle sequence.

The geographical distribution of direction lines in orientation calendars

Apart from direction lines relating to sunrises or sunsets on zenith passage days, so far no regional differences have been noticed in the above-mentioned sun calendars with 20-day periods. Because of its symmetry with regard to the summer solstice and the equal intervals to the zenith passage days in latitudes 15° and 20.5° N., the structure of the calendar presented in table 1 corresponds entirely to the orientation calendar based on Sahagún. Variations are due to the respective position of the five remaining days, or *nemontemi* days. Yet, it is not possible to say that orientation calendars of this kind are typical of any particular region. Even the 9° direction (table 1) which seems so typical of the Maya area and occurs only rarely in Central Mexico, can be found in the depiction of a calendar wheel for Central Mexico covering the last day of period III on April 12 (Tichy 1981, fig. 10).

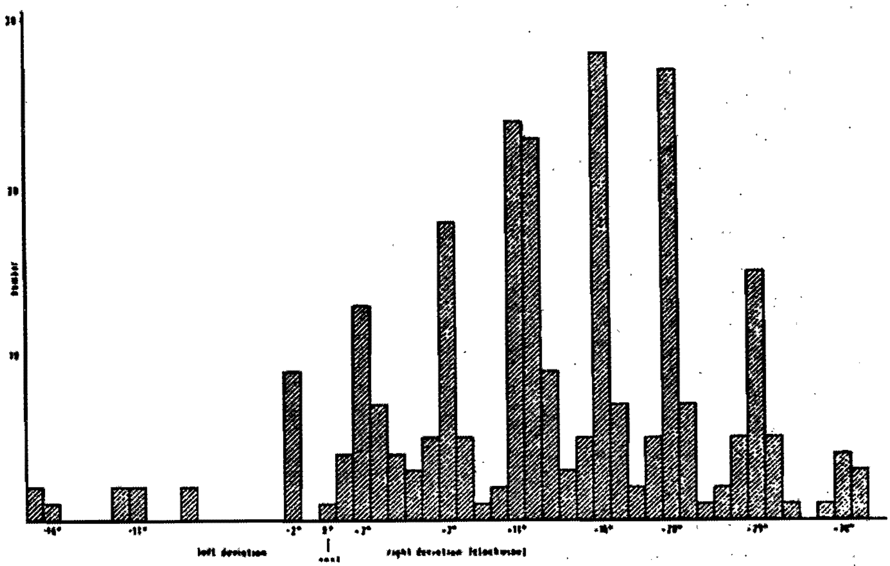

FIG. 1. Histogram showing the distribution around astronomical east of the axes of 280 churches in the Basin of Mexico (after Tichy 1976/81, fig. 6).

What about the spatial separation of the summer —and winter sequences or the sunrise and sunset types in the two different angle series of table 2? Is it feasible to speak of a Maya sunrise-winter type? How clearly can we separate areas of distribution, and how far do they penetrate each other?

The summer sequence of table 2 with the observation of the sunsets corresponds convincingly to the angle sequence revealed by the studies of settlement patterns. For Tenochtitlan (7°) and 18 other sites (churches) in the Basin of Mexico we get a sunset on April 5; for Tlatelolco, Xochimilco, Tlahuac (11°-12°) and for another 44 sites the orientation line points to sunset on April 18; for Teotihuacan with 16°-17° the date is May 1, as it is for another 28 sites, most of them in the vicinity of Teotihuacan; the pyramid of Santa Cecilia, the town and church of Amecameca and 27 sites follow the 20° direction. The 25°-26° direction towards sunset on the summer solstice is above all documented over a large area in the Basin of Puebla-Tlaxcala with Cholula, but also in the Basin of Mexico, mainly east of Teotihuacan in and around Otumba (see maps in Tichy 1976a and 1976b p. 126).

In addition to these most common orientation lines that are part of the summer sequence, there exist, however, in Central Mexico others, belonging to the winter sequence. In this context the axial positions of 5°, 9°, 14° and 18° are to be revised. The town of Texcoco is probably the most interesting case with the 4°-5° orientation. Despite the great significance of this town in Aztec times so far no traces of pre-Spanish buildings have been found that would permit a direction to be measured. The huge ecclesiastical complex of Texcoco with churches and chapels oriented to the four cardinal points, always displays a deviation of approximately 4°. There are another four sites with 4° and 3 with 5°. The 9° orientation is very rare, with a single site in the Basin of Mexico and two in Puebla-Tlaxcala, but there exist two pyramids near Oaxaca and Huitzo (Storck 1980, fig. 4). It is striking that there are eleven sites with 13°, among them the monastery of Coatepec and the monastery of Tultitlan with five nearby sites. The 18° direction exists as four sites in the Basin of Mexico, including the ancient pilgrimage church of Guadalupe, and at twelve sites in the Puebla-Tlaxcala area. Because of possible measurement errors it cannot be excluded that these sites may rather belong to the orientation group of 16°-17°.

In the Valley of Oaxaca buildings measured for their orientation by Aveni and Hartung on Monte Alban have the 4°-5° direction (Aveni 1980, Appendix A). The general direction of the mountain ridge with a similar deviation from North to East also makes their orientation understandable. This topographical position together with the solar calendrical orientation must have increasead the importance of this site, just as in the case of Teotihuacan. The ball court of Atzompa near Oaxaca with its 4°15′ is a further example. K. A. Storck (1980, 1981) has shown that in the Valley of Oaxaca, the settlements and ceremonial centers belong, with regard to their orientation, with very few exceptions —the most significant of which is admittedly Monte Albán— to those areas of Mesoamerica in which the summer sequence with the sunset observation seems to have been used to orientate settlements and ceremonial centers.

Conclusions

An examination of the properties of the hypothetical orientation calendar with 13-day weeks presented here, leads to the conclusion that by means of such a calendar it is possible to explain the orientation lines of ceremonial centers and settlement patterns observed and measured both in the Maya area and in Central Mexico. Although we are dealing with one single calendar, it contains nevertheless, with its two different sequences of angles —the winter and the summer series—, two differing conceptions and observational methods that were subsequently applied in planning. When the winter —or Maya type is found outside the Maya area, as is the case of Monte Albán, that should be a reason to look for further common features or connections. There is also reason enough to assume that the structures with the small deviation of around 1°, i.e. the mid-year direction, should be ascribed to the winter type. Xochicalco and Cacaxtla were cited as examples for apparent connections with the Maya area. On the other hand, the influences of Central Mexican architecture are to be connected with the 16°-17° orientation in North Yucatan and have always been interpreted in this way, especially as the latitude coincides. However, in the case of other latitudes a more cautious approach must be adopted when making such comparisions with the Teotihuacan direction since at 15° n.L. the sunset direction on the days of the zenith passages results in exactly the same orientation line (table 2).

BIBLIOGRAPHY

AVENI, Anthony F.
1980 *Skywatchers of Ancient Mexico.* University of Texas Press, Austin and London.

AVENI, Anthony F. and Horst Hartung
1976 "Investigación preliminar de las orientaciones astronómicas de Copán." *Yaxkin* 1: 2-13. Tegucigalpa. Instituto Hondureño de Antropología e Historia.

1986 "Maya City Planning and the Calendar." *Transactions of the American Philosophical Society* 76, Part. 7: 1-87.

BRICKER, Victoria R.
1982 "The Origin of the Maya Solar Calendar." *Current Anthropology* 23: 101-103.

BRODA, Johanna
1982 "Astronomy, Cosmovisión, and Ideology in Prehispanic Mesoamerica." in *Ethnoastronomy and Archeoastronomy in the American Tropics* (Anthony F. Aveni and Gary Urton, eds.): 81-110. Annals of the New York Academy of Sciences 385. New York.

GIRARD, Rafael
1962 *Los Mayas eternos.* México.

GRAULICH, Michel
1981 "The Metaphor of the Day in Ancient Mexican Myth and Ritual." *Current Anthropology* 22: 45-60.

1984 "Tozoztontli, Huey Tozoztli et Toxcatl, fêtes aztèques de la moisson et du milieu du jour." *Revista Española de Antropología Americana* 14: 127-164. Madrid.

KÖHLER, Ulrich
1982 "On the Significance of the Aztec Day Sign 'Olin'," in *Space and Time in the Cosmovision of Mesoamerica* (Franz Tichy, ed.): 111-127. Lateinamerika-Studien 10, Wilhelm Fink Verlag, München.

MALMSTRÖM, Vincent II.
1973 "Origin of the Mesoamerican 260-Day Calendar." *Science* 181: 939-941.

1981 "Architecture, Astronomy, and Calendrics in Pre-Columbian Mesoamerica," in *Archaeoastronomy in the Americas* (R. A. Williamson, ed.): 249-261. Anthropological Papers 22, Ballena Press, College Park, Maryland.

Merrill, Robert H.
1945 "Maya Sun Calendar Dictum Disproved." *American Antiquity* 10: 307-311.

Nowotny, Karl A.
1968 "Die aztekischen Festkreise." *Zeitschrift für Ethnologie* 93: 84-106. Braunschweig.

Storck, Karl-Ludwig
1980 "Die Orientierung von Orts-und Flurgrundrissen im Becken von Oaxaca/Mexiko." *Lateinamerika-Studien* 6: 139-163. Wilhelm Fink Verlog, München.

1981 "La orientación de los planos de poblados y campos en el Valle de Oaxaca, México," in *Economía y conciencia social en México* (H.-A. Steger y J. Schneider, eds.): 91-111. UNAM, Escuela Nacional Estudios Profesionales Acatlán, México.

Tichy, Franz
1974 "Explicación de las redes de poblaciones y terrenos como testimonio de la ocupación y planificación del Altiplano Central en el México Antiguo". *Comunicaciones* 11: 41-52. Puebla. Fundación Alemana para la Investigación Científica.

1974 "Deutung von Orts und Flurnetzen im Hochland von Mexiko als kultreligiöse Reliktformen altindianischer Besiedlung." *Erdkunde* 18: 194-207. Bonn.

1976 "Ordnung a und Zuordnung von Raum und Zeit im Weltbild Altamerikas. Mythos oder Wirklichkeit?" *Ibero-Amerikanisches Archiv* N. F. 2: 113-154. Berlin.

1976 "Orientación de las pirámides e iglesias en el Altiplano Mexicano." *Suplemento Comunicacoines* IV: Puebla. Fundación Alemana para la Investigación Científica.

1978 "El calendario solar como principio de organización del espacio para poblaciones y lugares sagrados." *Comunicaciones* 15: 153-163. Puebla.

1979 "Configuración y coordinación sistemáticas de espacio y tiempo en la visión del mundo de la América antigua. Mito o realidad?" *Humboldt* 69: 42-60. München.

1980 "Der Festkalender Sahagun's. Ein echter Sonnenkalender?" in *Wirtschaft und gesellschaftliches Bewusstsein in Mexiko seit der Kolonialzeit* (Hanns-Albert Steger und Jürgen Schneider, eds.); 115-137. Lateinamerika-Studien 6, Wilhelm Fink Verlag, München.

1981 "Es el calendario de fiestas de Sahagún verdaderamente un calendario solar? en *Economía y conciencia social en México* (H.-A. Steger y J. Schneider, eds.): 67-89. UNAM, Escuela Nacional Estudios Profesionales Acatlán, México.

1976-81 "Order and Relationships of Space and Time in Mesoamerica: Myth or Reality?" in *Dumberton Oaks Conference on Mesoamerican Sites and World Views* (Elisabeth P. Berson, ed.): 217-245. Washington D. C. 1976, Copyright 1981.

1982 "The Axial Direction of Mesoamerican Ceremonial Centers on 17° North of West and their Associations to Calendar and Cosmovision," in *Space and Time in the Cosmovision of Mesoamerica* (Franz Tichy, ed.): 63-83. Lateinamerika-Studien 10, Wilhelm Fink Verlag, München.

1985 "Sonnenbeobachtungen und Agrarkalender in Mesoamerika", in *Gedenkschrift für Gerdt Kutscher* Teil 2. (R. Mönnich, B. Riese und G. Vollmer, eds.): 99-112. Indiana 10. Berlin.

1988 "Measurement of Angles in Mesoamerica. Necessity and Possibility," in *New Directions in American Archaeoastronomy* (R. F. Aveni, ed.): 105-120. Proceedings 46. International Congress of Americanists. Amsterdam, Netherlands 1988. BAR International Series 454. Oxford.